Chapter IV

Factors Affecting Quality of Tea: A Model
4.1 Tea Quality

The term ‘Tea Quality’ in its broadest sense for made tea is used as a description of all the characteristics viz., appearance, cup-characteristics or in other words liquor qualities such as colour, brightness, strength, aroma and finally characteristics of infused leaf which determine its market value. So, in general, evaluating tea quality means a summation of the desirable attributes comprising internal and external characteristics. (Garodia, P.; 1979)

In trade circle the term quality for made tea is commonly used to indicate the presence of some special desirable characteristics in the liquor. In this sense, the term quality of a cup of Tea is partly sensation in the mouth, partly an aroma and partly the appearance.

4.2 Exploration of Factors Affecting Tea Quality

Here an attempt has been made to investigate and analyze the process of tea production in tea gardens with an objective of improving the quality of made tea.

In such an attempt, it is essential to make an assessment of the factors affecting the quality of tea. In addition to the survey of literature, several visits were made to a garden in Assam that produces premium tea in terms of auction price, to assess the factors affecting the quality of tea. Moreover, small tea growers, experts from Tocklai Tea Research Association, Jorhat (Assam), Assam Agricultural University, Jorhat (Assam) were also consulted while developing the causality model.

Thus, the factors which affect the tea quality were determined by:

- extracting knowledge of the managerial level people, supervisors, workers of the tea gardens through systematic Questionnaire Survey
- investigative conversation with the people related to tea industry
- extensive study of literature on the subject

Based on the findings, the factors affecting the quality of tea are classified into eight categories:

1. Genetic Factors
2. Environmental Factors
3. Cultural Factors
4. Leaf treatment Factors
5. Factory Hygiene Factors
6. Maintenance Factors
7. Labour Factors
8. Processing Factors

4.2.1 Genetic Factors

The tea quality determined by the genetic properties is based on the chemical composition of the leaf, such as Polyphenol content, Protein nitrogen component, Leaf pubescence, Planting Materials, etc. (Baneerjee, B.; 1993)

The polyphenolic group makes up about 30% of the solid matter of the tea shoot. The polyphenols are popularly known as tannins, although they have no tanning properties. The polyphenolic bodies in tea shoot decrease in quality from bud to stalk. A sample of shoots of Assam leaf, for instance, shows that the polyphenols make about 35% of dry matter in the bud and first leaf, 28% in the second leaf and 15% in the stalk with a total polyphenolic content of the shoots of 30%.

The quantity and proportion of polyphenols present in green leaf generally is reflected in the chemical composition of the made tea in the liquor characteristics. The colour, strength and pungency of the infusion in the fermented black tea depend mostly on the polyphenolic content. The greater the polyphenolic content the greater are the Briskness, Strength and Colour.

A high content of caffeine is one of the factors indicating a good quality tea. Maximum caffeine content is found in the newly formed leaves and buds. The coarser leaves and stem have lower caffeine content.

Proteins combine with the oxidation products of fermentation and lead to insoluble products which are harmful from the quality point of view of tea. So, high protein content in the leaf is an undesirable factor. (Dhan, I.K.; 1995)

The tea made from pubescent leaves (leaves without hairs) and buds are superior to the tea made from leaf with hairs. Polyphenols, Caffeine and Carbonyl compounds are
present in greater amounts in the hairy leaves than in non hairy leaves. The Carbonyl compound increases the flavour of the tea.

Since the best possible tea cannot be made without the best leaf, so due attention should be paid to the genetic properties of the leaf and with it to the planting materials for new tea plantings. Choice of proper tea clone is the first step towards a brighter future of a garden. (Das S.C. et al., 2002)

The genetic properties of the leaf vary from country to country, from plantation to plantation, from field to field and even from bush to bush. The genetic factors affecting the quality of made tea are shown in the Ishikawa Cause and Effect Diagram in Fig 4.1.

![Ishikawa Cause and Effect Diagram](image)

**Fig 4.1**
The Genetic Factors Affecting the Quality of Made Tea

The Causal relationships of the various factors are shown in Fig. 4.2
4.2.2 Environmental Factors

The environmental conditions affect the natural growth of the tea plants, their composition and leaf characters thus show a great effect on the quality of the tea.

Both soil and climate affect the tea quality but especially the climatic conditions including Temperature, Air humidity, Sunshine, Rainfall and Day length are of importance. Soil pH, bulk density of soil, soil temperature, soil tillage, moisture content of soil, organic carbon content of soil affects the volume and quality of tea production. (Barooah et al, 2002)

Tea made from second flush (dry season) in Assam valley have higher concentration of the important constituents in the leaf which are responsible for high quality tea than the tea produced in the rainy season. The areas with well-distributed
rainfall and uniform temperature result in even growth and regular cropping, where the productivity is generally high but tea quality is moderate to low.

High altitude plantation tea leaves results in the production of made tea of high quality and outstanding flavour. Tea produced at higher altitudes is of better quality than medium or low grown tea. This is due to lower temperatures at higher elevations and to the corresponding slower growth as polyphenol contents are found to be higher in the period of slower growth under conditions of dry weather and ample sunshine.

Experiments conducted in Sri Lanka, Java and Sumatra showed that leaf grown at a lower elevation, but processed in factories at higher altitudes gave teas of improved quality, brighter liquor and brighter infused leaf. (Barua, P.C.; 1984)

Chlorophyll plays an important role in the formation of colour of the made tea. The chlorophyll formation depends on sunlight and so its content varies with environmental conditions like altitudes, shade and other factors. Low grown leaf and rainy season leaf contain more chlorophyll and the tea made from such leaves are therefore blacker than those produced from high grown leaf and dry season leaf.

The Causal relationships of the environmental factors are shown in Fig. 4.3
4.2.3 Cultural Factors

Cultural factors represent the plantation practice of a garden. These factors include: Standard of plucking, Fertilizing, Shading, Pruning, Irrigation, Pest management, etc.

Good tea is the product of good leaf in the first place. Since the quality of tea depends upon the composition of the plucked leaf, it is indirectly affected by the plucking interval. Plucking should be carried out at such interval (7-10 days), so that no too many shoots left from the previous round are plucked in an overgrown stage, nor too few shoots have developed in the mean time to make plucking worthwhile. Flush shoots of two leaves and a bud obtained by fine plucking ('two leaves and a bud') are the best material, because of the high contents of polyphenols and caffeine. Further more, the physical property of fine leaf is most suitable for processing into good tea.

Since the objective of plucking is the commercial production of high quality tea at the highest possible level throughout the life time of a tea plant, plucking and other measures of bush management should be carried out efficiently. Not only adequate leaf of good standard should be plucked, but sufficient mature leaf should be left on the bush.

Bud and first leaf are the richest sources of polyphenols and caffeine; the leaves lower down and the stems are proportionally poorer in these constituents.

Leaf plucked in the morning produces better tea than leaf plucked in the evening. This is caused by higher polyphenol content produce from sugars and by higher amino-acid content produced from proteins during the night. Another cause is the better leaf plucking in the morning compared to careless plucking in the afternoon.

Under some environmental conditions, shading increases the yield and quality of tea while in some other environmental conditions it has a depressing effect on quality.

Findings in Japan show that the tea grown under shade have low polyphenol content, which affect the quality. In Assam, shade is beneficial and is even necessary for successful cultivation of tea. In Assam, shade reduces the natural light intensity by about 50% and usually increases the yield, but it does not affect tea quality adversely (Phukan, B. C., 2002 and Barthakur et al., 2002).

In general, possibly related to changes in the growth rhythm of the bush, the quality of tea is affected by the age of pruning. Generally tea quality improves with higher
age both for planting and pruning. Leaves harvested directly after pruning is large and watery, low in polyphenol contents and high in nitrogen content. Experimental studies in the field of pruning say that with a shorter pruning cycle, a better colour and strength of tea are obtained. Tea obtained from gardens younger than fifteen years are of lower quality than tea from older gardens.

The Causal relationships of cultural factors are shown in Fig. 4.4

![Causal Relationship among the Cultural Factors Affecting Quality of Tea](image)

4.2.4 Leaf Treatment Factors

One of the important tasks in maintaining quality of tea is the careful handling of green leaf. For best results in the factory due care and attention should be given to the green leaf both in field, during transport and before withering. Care should be taken in the following areas:
Ishikawa Cause and Effect Diagram Showing the Environmental and Cultural Factors Affecting the Quality of Made Tea
4.2.4.1 Treatment During and After Plucking

(i) While plucking, bruising of leaves should be avoided.

(ii) Leaf should be handled with care and packed lightly to remain cool and undamaged as rough handling and tight packing result in damage and heating up of the leaf.

(iii) Contamination with foreign matter, e.g.: sand and soil should be avoided.

(iv) Since pluckers are usually paid on the basis of quantity of leaves plucked, strict inspection is required to avoid all kinds of malpractices such as hiding heavy stones or extra moisture with the purposes of increasing the weight. A paying system based on both quality and quantity of the plucked leaf is desirable.

4.2.4.2 Treatment During Transportation

(i) Plucked leaf should be delivered at the factory as quickly as possible avoiding any damage during transportation

(ii) The containers should be stalked lightly to allow air to pass through.

(iii) After arrival at the factory withering should be started with the least possible delay.

(iv) Leaf awaiting withering should not be stored in sacks or baskets or in heaps.

Despite every precaution, leaf arriving at the factory may reach a temperature up to 32°C depending on ambient temperature. Negligence in packing and transporting of leaf could therefore result in much higher temperatures leading to loss in quality.

The modes of filling the leaf in the container lead to growth of bacteria. Table 4.1 shows the rate of bacteria formation in different modes of filling tea in basket used for carrying tea.

### Table 4.1

#### Number of Bacteria in 1 Gram of Leaf Depending on the Method of Packaging

<table>
<thead>
<tr>
<th>Mode of filling the basket</th>
<th>Temperature in the Mass of Leaf in Degree Centigrade</th>
<th>Number of Bacteria in 1 Gram of Leaf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loosely Packed Leaf</td>
<td>26</td>
<td>10000</td>
</tr>
<tr>
<td>Compactly Packed Leaf</td>
<td>34</td>
<td>120000</td>
</tr>
</tbody>
</table>
The factors related to leaf treatment affecting the quality of made tea are shown in the Ishikawa Cause and Effect Diagram in Fig. 4.6

**Fig: 4.6**
The Leaf Treatment Factors Affecting the Quality of Made Tea

The Causal relationships of the various factors are shown in Fig. 4.7

**Fig 4.7**
Causal Relationship among the Leaf Treatment Factors Affecting Quality of Tea

### 4.2.5 Factory Hygiene Factors

Tea being within the purview of food and beverage industry it is important to maintain a clean and pollution free condition inside and even immediately outside the
factory premise. Moreover, for production of top quality tea, the factory must be airy and clean. Even a slight contamination of bacteria is sufficient to reduce the brightness and briskness of the liquor.

The factors related to Factory Hygiene affecting the quality of made tea are shown in the Ishikawa Cause and Effect Diagram in Fig. 4.8

![Ishikawa Cause and Effect Diagram for Factory Hygiene](image)

**Fig: 4.8**
The Factory Hygiene Factor Affecting the Quality of Made Tea

The Causal relationships of the various factors are shown in Fig. 4.9

![Causal Relationship among Factory Hygiene Factors](image)

**Fig 4.9**
Causal Relationship among the Factory Hygiene Factors Affecting Quality of Tea
4.2.6 Maintenance Factors

Maintenance is an important function of the tea estate and is primarily concerned with controlling condition of productive equipment and other capital assets. Maintenance activities in the factory of a tea garden are affected by working conditions. Safety, inspection procedure and the frequency of inspection, quality of safety instructions, the work activities, proper maintenance of the engineering records, the size of maintenance crew, setup of the maintenance staff and devotion of maintenance personnel etc. determine the level of maintenance function in a tea garden. (Ghose, S.; 1999)

The factors related to maintenance affecting the quality of made tea are shown in the Ishikawa Cause and Effect Diagram in Fig. 4.10

The causal relationships of the various factors are shown in Fig. 4.11

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Chapter IV: Factors Affecting Tea Quality
4.2.7 Labour Factor

Reports from Managers of different tea gardens pointed out that one of the main problems of most of the Tea Gardens is the labour related problem, specially the problem of absenteeism of labourers.

The factor has an indirect effect on tea quality. The various factors which affect the motivation level of labourers are:

1. Promotion strategy of the management
2. The value or volume of work
3. The procedure of discharging workers
4. The duration of work and wages
5. Communication gap with the management
6. Location of the factory
7. Welfare standards adopted by the management
8. The level of education of the labour force

The factors related to labourers affecting the quality of made tea are shown in the Ishikawa Cause and Effect Diagram in Fig. 4.12
The causal relationships of the various factors are shown in Fig. 4.13

![Causal Relationship among the Labour Factors Affecting Quality of Tea](image)

**Fig 4.13**

Causal Relationship among the Labour Factors Affecting Quality of Tea

4.2.8 Process Factors Affecting Quality of Tea

All the processes involved in the tea processing play an important role in building the quality of tea. It should always be kept in mind that only careful and proper processing will bring out the full potential of the green leaf.

4.2.8.1 Factors of Withering Process Affecting Quality of Tea

The object of withering is to produce from varying batches of leaf a residual material with uniform moisture content. It is used to prepare the leaf for the rolling process by making the leaf tissues flaccid and permeable to juices which the rolling will wring out and spread evenly upon the surface.

The process of withering is normally carried out by spreading thinly on banks of trays or ‘tats’ made of tightly stretched jute Hessian or wire netting. 2 or 3 sq. meters/kilograms of fresh leaf are a normal density of spread. The tats are spaced 14 cm apart, to allow free access of air, with alleyways of each bank to allow distribution and removal of leaf.

In Assam, the open or ‘chung’ type of withering process adopted has no control on rate of withering. In this type, the withering process is controlled by adjusting the
thickness of spread and the length of wither is dependent entirely on the prevailing hygrometric conditions of the ambient air. The withering houses are generally detached from the rest of the factory and have no walls. During wet weather conditions the relative humidity of air is decreased by blowing air from outside by means of fans.

4.2.8.1a Bio-chemical changes in withering

After plucking, enzymic activity and soluble amino acid content increase for 20 hours; thereafter the changes are erratic. Caffeine, however, increases throughout the experimental period (72 hours). On the other hand, actual withering is necessary to bring about increasing permeability of cell membranes on which, to a considerable degree, the mingling of enzyme, polyphenols and oxygen depends in orthodox manufacture. Enhanced enzyme efficiency promotes quicker and more efficient fermentation; amino acids are thought to influence colour and aroma. Caffeine is a stimulant that makes tea a desirable beverage. (Khanna, A.I.N.; 1999)

4.2.8.1b Effects of improper withering

Too light wither will overtax the drier in the firing process. Under-withering tends to produce flaky tea of low apparent specific gravity. The red leaf in the dried tea increases if withering is too tight. This reduces the appearance of tea. With long withers there is a risk of the rapid formation of unwanted bacteria which produce dull tea having low quality characteristics.

The factors which affect withering process are thickness of spread, condition of leaf, period of wither, standard of plucking, etc.

4.2.8.1c Type and condition of leaf

The rate of wither is markedly influenced by the type of leaf i.e., clone or 'jat', pruned or unpruned, the size and the general composition of the plucked material etc. Tender leaves diffuse moisture at a faster rate than the mature leaves or the stalks. When the leaf is of a mixed pluck, a considerable variability or unevenness on the wither can be expected

4.2.8.1d Thickness of spread

Depending upon the various factors like type of leaf, size, condition and thickness of leaf spread may vary between 8-20 cm and may be a quite critical factor in determining the quality of the finished product.
4.2.8.1e Period of wither

This is ascertained by taking both physical and chemical wither into consideration. Though physical wither is achievable within 3-4 hrs, chemical wither requires 12-16 hrs for completion and therefore, it is necessary to wither the leaf for a minimum period of 12-16 hrs.

4.2.8.1f Drying capacity of air

The drying capacity of air used for withering is determined by factors like hygrometric difference, temperature, volume of air and its movement and pressure exerted by air. When there is surface moisture in the leaf, the humidity potential of air surrounding the leaf controls the evaporation. Humidity potential of air is an inverse function of the humidity of air. Higher the humidity lower is the humidity potential and vice-versa. The humidity potential of highly humid air can be increased by raising the temperature by external means.

The temperature of leaf withering is an important parameter. There are harmful effects of withering at higher temperature. The surface temperature of a wet leaf usually comes closer to wet bulb temperature of air. But as soon as the surface becomes dry, the temperature rises to dry bulb temperature of the air. Therefore, while using hot air, one should use lower dry bulb temperature. Supply of hot air at 32°C (90°F) and with a hygrometric difference of 6°C (11°F) has been found to be useful in giving a good wither and yielding good quality tea. Moreover, during withering hot air should be used only during the earlier part and not afterwards.

It may be noted that theoretically the amount of energy in the form of latent heat required to evaporate 1kg of water is same both for withering and drying. Since the process of withering is carried out at lower temperature, volume of air required for withering is very high. But too high a flow is likely to produce leaf with uneven wither. On the other hand restrictions of the fan inlet area can result in reduced flow rates and affect the withering process adversely. Table 4.2 shows the effects of under-wither, over-wither and correct wither of tea leaves on processing.
Table 4.2
Effect of Under-wither, Over-wither and Correct-wither During Processing

<table>
<thead>
<tr>
<th>Effects on</th>
<th>Under Wither</th>
<th>Over Wither</th>
<th>Correct Wither</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>Open and flaky</td>
<td>Well twisted</td>
<td>Well twisted</td>
</tr>
<tr>
<td>Rolling</td>
<td>Considerable expression of juice during rolling involving loss of solids responsible for liquor characteristics</td>
<td>Hard pressure must be employed involving possible loss of tips</td>
<td>Little expression of Juice</td>
</tr>
<tr>
<td>Tips</td>
<td>Loss of tips during rolling and pale colour of tips in made tea</td>
<td>Silvery tip due to insufficient juice deposit on the hair of bud</td>
<td>Golden appearance of tip</td>
</tr>
<tr>
<td>Possibility of bacterial infection</td>
<td>Very high</td>
<td>Under control</td>
<td>Under control</td>
</tr>
<tr>
<td>Stewing</td>
<td>Possibilities exist during drying</td>
<td>Unlikely</td>
<td>Possibilities minimized</td>
</tr>
<tr>
<td>Liquor</td>
<td>Inferior in every respect with a possible brassy taste</td>
<td>Considerable loss in colour and strength</td>
<td>Normal liquor characteristics</td>
</tr>
</tbody>
</table>

The causal relationships of the withering process factors are shown in Fig.4.14

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Fig 4.14
Factors of Withering Process Affecting Quality of Tea

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4.2.8.2 Factors of Rolling Process Affecting Quality of Tea

When a satisfactory wither has been obtained the leaf is ready for rolling, which twists the leaf, breaks it up and expresses the juices. The rolling process is intended to initiate fermentation and find a balance between appearance and liquor. The object of rolling withered leaf is two folds:

- To rupture the leaf cells and release enzymes, and
- To give a curl or twist to the leaf.

Rolling initiates the process of fermentation. In green leaf catechins and enzymes remain apart; when leaf cells are ruptured these come together and in the presence of atmospheric oxygen, form into Theaflavins (TE) and Thearubigins (TR). (Das, et al., 1999)

The rolling process demands due care in deciding the number of rolls required and the period of rolling. The rolling process factors contributing to tea quality are:

- Condition of leaf after withering
- Roller charge and speed.
- Pressure applied on leaf in Rolling Process
- The rolling temperature.
- The type of tea required

Factors that prevent excessive heat generation during rolling and in consequent loss of quality and flavour are:

- Good leaf circulation.
- Raising the pressure caps of rollers at intervals.
- Reduced charge particularly for later rollers under high pressure
- The use of cold humid air in the rolling room.
- Reduced rolling period and light wither.

The causal relationships of the fermentation process factors are shown in Fig. 4.15
4.2.8.3 Factors of Fermentation Process Affecting Quality of Tea

Fermentation process is considered to be one of the most important processes in Black Tea processing as most of the desirable properties of tea are produced during this process. The most important characteristic components of tea leaf are polyphenols in the cell sap. During fermentation, some of the polyphenols are converted to compounds which are mainly responsible for liquor qualities of a cup of tea. (Goswami, et al., 1999)

The process of Fermentation is mainly affected by the rate and period of fermentation and the fermenting temperature (Dhan. I. K.; 1995). However, all the important characters of tea are not developed at the same rate. Briskness, Strength and Colour (with milk) changes with time and temperature. Each character is at its best at different times. It may happen that where, as a rapid fermentation at a high temperature suits a certain tea, a longer fermentation at a lower temperature might prove more suitable for others. The most suitable temperature under given condition will depend on the characters the made tea is required to have. By shortening or lengthening the period of fermentation, the degree of colour and quality can be varied to suit different requirements.

The other factors, which affect the tea quality, are as follows:

- Leaf characters
- Density of spread
- Fermenting condition
- The degree of leaf distortion during rolling etc.
The factors of this process contributing to quality of made tea are discussed below:

4.2.8.3a Period of fermentation

During fermentation the colour of the processed leaf changes from green to coppery-red and the liquor characteristics develop. The important liquor characteristics are briskness, flavour, colour and strength (Dhar. T.K.; 1999). The effect of fermentation period on tea quality is shown in the fig 4.16

![Fig. 4.16](image)

Effect of Fermentation Period on Tea Quality

The reaction during the fermentation process and variations in the development of characters are shown in the figure 4.17

![Fig. 4.17](image)

Reaction During Fermentation Process

It is apparent that no two liquor characters are at their optimum at the same time. When the strength is at its best, the briskness has already fallen off. Depending on the severity of the treatment and the type of leaf, the length of fermentation should be a compromise among all the liquor-characters. As it has been explained above, more severe the cut, the less is the fermentation time required. Thus CTC manufacture requires lesser...
4.2.8.3b Fermenting condition

Temperature has a profound effect on the process. At lower temperature more TF is formed. TFs are related to the brightness of the liquor (infusion) and TRs to its depth (body and strength) ideal fermentation produces a proper balance of TFs and TRs.

It has already been stated that the room temperature should not exceed 29°C (85°F) during fermentation. In North East India the temperature invariably is higher in the afternoon and the air humidity is low. This results in the leaf surface becoming dry and black. The fermenting room should have provision for humidified air to keep the room cool and fresh. The temperature should be maintained at 29°C ± 1°C with a hygrometric difference of 1.5°C (2°F) (Ravindranath, S.D., 1999). Adequate ventilation is to be provided to effect regular air changes.

The initial oxidation of polyphenols is greatly influenced by temperature. The enzymic oxidation proceeds most rapidly at about 29°C (85°F), and above and below this temperature the activity is dropped. Most of the enzymes are destroyed at about 54°C (130°F). The changes from the oxidised polyphenols to various TFs and TRs are chemical and, therefore, increase at higher temperature. Since both enzymic and chemical oxidations proceeds at different rates at different temperatures, it is difficult to decide the optimum fermentation time.

Fermentation is more active between 27-29°C (80-85°F) and completely stops between 54 - 65°C. It is therefore desirable that at the green leaf processing stage the temperature is maintained at around 29°C (85°F).

4.2.8.3c Assessment of fermentation

Fermentation is currently assessed in the factory by visual inspection and "Nose" test. While one may be quite lucky in lifting the leaf at the right fermentation time, however, on most occasions the leaf is picked up after it has been over fermented.

4.2.8.3d Degree of wither

Characters of both the withered and the rolled leaf affect fermentation. An uneven withering usually results in uneven fermentation. Fermentation can be at its best when the leaf has the right physical condition and the cells are permeable which allow oxygen to diffuse more quickly into the leaf. In unwithered leaf the juice is usually expelled during
rolling. The juice contains soluble components and their loss will result in poorer quality tea. It is, therefore, desirable that only as little juice should be expressed as is necessary for proper mixing with the rolled leaf.

4.2.8.3e Rolling

During rolling, the tender leaf parts are bruised first, and then only the hardened leaf parts are disintegrated. Thus the fermenting requirements of the fine particles will be different from those of the coarse particles. The coarse particles, however, can be fermented as well as fine leaf at the same rate if the same number of cells are disintegrated by applying adequate pressure. The rupturing of cells in the coarse leaves thus requires longer rolling time. The various fractions of leaf produced by the repetitive rolling are fermented separately for different periods. Tightly twisted leaf, as produced in orthodox manufacture, is difficult to be penetrated by air, and as such it takes longer fermentation time. Similarly, severe distortions during CTC manufacture help in quicker fermentation because of easier oxygen penetration.

The causal relationships of the fermentation process factors are shown in Fig. 4.18

![Causal Relationship among the Fermentation Factors Affecting Quality of Tea](image)

Fig 4.18

Causal Relationship among the Fermentation Factors Affecting Quality of Tea

4.2.8.4 Factors of Drying Process Affecting the Quality of Tea

The objectives in drying (commonly called firing) are:

- to arrest the fermentation and to fix the desirable properties.
- to obtain a finished product that is stable and can be handled and transported
When a mass of macerated leaves has attained the required stage of fermentation, it is fired, or exposed to hot air. The objective is to arrest further fermentation by killing all enzymes, as well as render the tea leaves almost totally dry. Since the moisture content of fermented leaves is around 60-66%, for every 3kg of fermented leaves subjected to firing, approximately 1kg of dry tea will be manufactured.

4.2.8.4a Air temperature

Drying of tea, unlike other solids, involves two aspects viz. physical and chemical as mentioned earlier. Therefore, the temperature at which the tea is fired has to be judiciously examined for its suitability. Too high temperature at the initial stage may result in case hardening and blistering. But even if these effects are avoided, a faster rate of evaporation at the initial stage of drying may impart the tea an undesirable harshness due to relatively higher proportion of un-oxidized or partially oxidized matter present in the finished product. On the other hand, too low a drying temperature will slow down the rate of drying and at undesirable high temperature fermentation will be allowed to proceed for a much longer period. This will form a product which will be dull and soft and which may ultimately result in 'Stewing'. In practice an inlet temperature between 82° to 99° C (180° - 210° F) has been found to be satisfactory, keeping in view the economy and efficiency of the drying operation and the liquoring properties of the resulting tea.

Exhaust temperatures, like the inlet temperature, are also important as they indicate the amount of heat extracted from the air stream to dry the leaf. For the existing dryers an exhaust temperature of 49°-54° C (120°-130°F) is advocated. At this temperature, the stewing inside the dryer is minimized and the fermentation of leaf particles in the top tray is brought nearly to a stop.

4.2.8.4b Volume of air

The volume of air required for drying is largely dependent on two factors:

- moisture to be removed
- the drying temperature

The difference between the inlet and the true exhaust temperatures during the first fire is roughly proportional to the amount of moisture evaporated per hour. Other things being equal, any increase in the inlet temperature is usually accompanied by a corresponding increase in the exhaust temperature. Changing of air flow is the easiest method of adjusting the drying condition. If the volume is below normal requirements,
the temperature will have to be increased to produce the same amount of heat. The capacity of dryer, however, can be increased by the air volume. Insufficient air flow in a dryer may be due to lower fan speed, small exhaust duct or due to partially closed fan valve. On the other hand, there is a limitation in increasing the air flow as too strong a blast will cause small pieces of leaf to be blown away from the dryer. The fan valve prevents excessive blow out. The drying air is most efficiently used in passing through the bed of leaf instead of just throwing the leaf off the tray because of too high velocity.

4.2.8.4c Thickness of spread

The spread of leaf in the dryer should be of reasonable depth to prevent the air from escaping freely through it. This can be best judged by the movement of the leaf particles in the air flow. Load and velocity of air should be such that the leaf in the upper tray is hardly disturbed, but on the lower trays it should bounce slightly. If no disturbance is observed in the lower trays, the leaf has been spread too thickly, or the air flow is insufficient. Overloading the dryer requires higher drying temperature and a longer drying period. It also sets up a back pressure baffling the air flow and gives uneven drying with loss in quality and irregular infused leaf. In general, a finer material should be spread thinner. Big bulk requires a slightly longer period of drying than fines and should be spread thicker. Spread thickness also depends on the degree of wither. Firing should never be attempted with a set spreader position. A dryer cannot be expected to adjust itself automatically to suit different types of leaves and variation in wither.

4.2.8.4d Period of drying

The time required to dry tea varies with temperature, thickness of spread and volume of air. It is apparent that the two main objectives of drying i.e., desired moisture content in the final made tea (which is normally 3%), and the optimal arrest of fermentation can be achieved even in shorter residence time by increasing the drying rate. It does not, however, necessarily mean that the evaporation rate is also high in such a case. A fast drying rate carries the danger of case-hardening of product. Longer period of drying on the other hand means higher spread thickness which will produce uneven tea due to unevenness in contact between particles and air supply.

Thus, the drying process is affected by the drying time, temperature of air, volume of air and the amount of leaf in each tray. These tea drying parameters should be adjusted in such a manner that good quality tea is produced. The causal relationships of the various factors are shown in Fig.4.19
4.2.8.5 Packaging and Sorting Factors Affecting Quality of Tea

After delivery from drier, the tea is spread out to cool and then temporarily stored to await sorting. Grading is carried out for the most part on mechanically oscillated sieves. These are fitted with the meshes of appropriate size. In some machines the sieves are in banks of diminishing mesh size such that the outfall of the upper member falls on the lower.

For various reasons, often it is not desirable to divide the tea into the greatest possible number of grades. The percentage of leaf suitable for the production of some of the grades is small and it may take too long to collect sufficient quantity of such leaf to make a large invoice to attract attention on the market. Tea grading percentage must, of course, vary according to plucking standards and the market demand. Grading of tea should be strictly of constant standard. The success of this product depends on whether the merit of tea is sufficient to attract particular attentions or not. (Punshi, R.C., 1997)

Normally the grades of tea produced by different gardens differ in quantity. Some estates may find it lucrative to make a particular grade while other estates may produce that particular grade in lesser quantity. The question as to which procedure gives the best return is a vexed one. Variations in grading ultimately cause a price variation in the market. Thus a fresh change in grading may be required for a garden to take advantage of the changed demand in the market.
After the tea has been sorted into respective grades, it is necessary to pack these in suitable containers to ensure that the keeping quality does not deteriorate in transit. All the efforts to prevent tea absorbing too much moisture will go in vain if due care is not taken in packing. Apart from tea chests having to meet certain standards, lining should be moisture-proof and free from foreign taint.

The present mode of packing is not absolutely air-tight and as a result tea does pick up more than 1.5% moisture by the time they reach the UK market. Tea packed in the garden with about 3% moisture may contain about 4-5% moisture, if not more, by the time it reaches UK. It has been found that absorption of this much amount of moisture by the tea before it is consumed has no harmful effect on the liquor characters of tea. In fact, despite this absorption of moisture, due to some chemical changes, the tea acquires mellowness which is a desirable character. It has been found that plywood tea chests with lining of alumina and tissue paper, metalized polyester or cellophane are suitable for packing tea.

Due to scarcity of plywood now-a-days, Tocklai Tea Research Association (TRA) has found an alternative material for bulk packing of tea. The sacks are made from Extensible Kraft Paper, comprising 5 layers of paper to hold about 50 kg of tea per sack. It is 120 cm long x 73 cm wide x 18 cm high.

4.2.8.5a Moisture content

The quality of tea tends to deteriorate at higher moisture content (over 6%) and higher temperature. So tea should preferably be dried to moisture content of 3%, be packed at 4 to 5% and further protected from excessive uptake.

4.2.8.5b Inspection

The sorted tea should be inspected for its different physical attributes. Tests are needed to ensure the absence of health hazardous substance like insecticides, pesticides etc.
4.2.8.5c Quality of packaging
The quality of packaging proves to be an important factor in the market for sales. Dull packaging fails to attract customers. Material for packaging decides the ex-factory quality of tea. Air tight packaging only ensures good quality at the customer's end.

4.2.8.5d Time between sorting and packaging
The moisture content of the final tea increases considerably with the increase of time between sorting and packaging. The Causal relationships of sorting and packaging process factors are shown in Fig.4.20

![Causal Relationship among the Sorting and Packaging Process Factors Affecting Quality of Tea](image)

Fig 4.20
Causal Relationship among the Sorting and Packaging Process Factors Affecting Quality of Tea

The Ishikawa Cause and Effect diagram of all the process factors determining quality of made tea is shown in Fig 4.21.
Ishikawa Cause and Effect Diagram Showing the Processing Factors Affecting the Quality Made Tea
4.3 CONCLUSION

The model, 'Factors Affecting Quality of Tea', classifies the factors into two major heads 'Management Controllable Factors' and 'Uncontrollable Factors'. The classification of factors under both the categories are shown in the Table 4.3

<table>
<thead>
<tr>
<th>MANAGEMENT CONTROLLABLE FACTORS</th>
<th>MANAGEMENT UNCONTROLLABLE FACTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEAF TREATMENT FACTORS</td>
<td></td>
</tr>
<tr>
<td>CULTURAL FACTORS</td>
<td>ENVIRONMENTAL CONDITIONS</td>
</tr>
<tr>
<td>MAINTENANCE FACTORS</td>
<td></td>
</tr>
<tr>
<td>PROCESSING FACTORS</td>
<td></td>
</tr>
<tr>
<td>CULTURAL FACTORS</td>
<td>GENETIC FACTORS</td>
</tr>
<tr>
<td>FACTORY HYGIENE</td>
<td></td>
</tr>
<tr>
<td>LABOUR</td>
<td></td>
</tr>
</tbody>
</table>

In the subsequent chapters (Chapter VI and VII) of this thesis an attempt has been made to:

- assess the level of awareness of these controllable factors among the people of Tea Industry in the light of TQM philosophy.
- develop an assessment tool which is expected to help the management to identify the problem areas where much stress is needed for improvement in quality culture of the garden.